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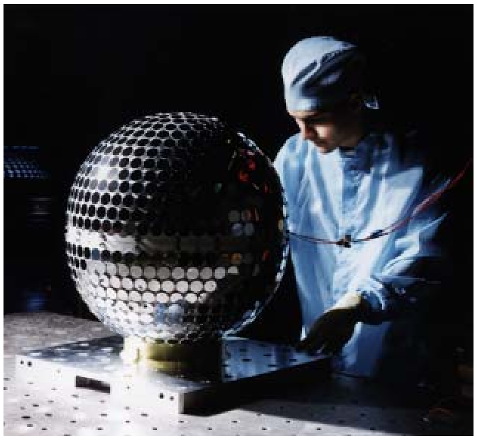
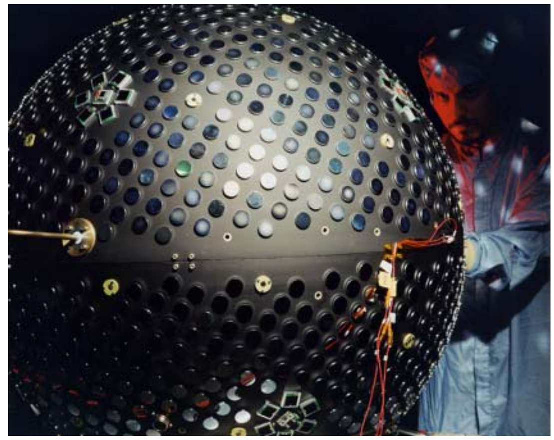


Starshine 2



Starshine 3

During the past six years, three small, optically reflective spherical "STARSHINE" student satellites have been designed by the U.S. Naval Research Laboratory and built by an informal, volunteer coalition of organizations and individuals in the USA and Canada. This coalition is called "Project Starshine" and is headquartered in Monument, Colorado. It receives no formal funding and operates by means of contributions of materials and labor from its member individuals and institutions. NASA has deployed the coalition's satellites into highly inclined low earth orbits from two Space Shuttles and an Athena expendable launch vehicle at no cost to the Starshine project, as a service to the international educational community. Each of the satellites is covered by approximately 1000 small, front-surface aluminum mirrors that are machined by technology students in Utah and polished by tens of thousands of students in schools and other participating organizations around the world. These mirrors have been coated with a scratch-resistant, anti-oxidizing layer of Silicon Dioxide by optical engineers and technicians at the Hill Air Force Base in Utah and the NASA Marshall Space Flight Center in Alabama.

The first of these satellites, called Starshine 1, was deployed into a circular orbit 387 kilometers (242 statute miles) high by the crew of Space Shuttle Discovery on June 5, 1999, near the end of Discovery's STS-96 mission to the International Space Station. Starshine 1 circled the earth every 90 minutes, descending and speeding up slightly during each orbit due to the effects of atmospheric drag, until February 18, 2000, when it was consumed by aerodynamic heating on its 4212th circuit of the earth at an altitude of approximately 80 kilometers (50 miles) above the Atlantic Ocean off the coast of Brazil. During the satellite's eight-month orbital lifetime, faint sunlight flashes from its student-polished mirrors were naked-eye visible against the star background, during certain recurring morning and evening twilight periods, to student and adult observers around the world between the latitudes of 60 degrees north and 60 degrees south.

These observers measured the satellite's right ascension and declination by reference to known stars, and they recorded the precise timing of their observations by the use of stopwatches synchronized with international time signals, such as Radio Station WWV in the USA. They used GPS receivers or United States Geological Survey 7 1⁄2 minute quadrangle maps, or their equivalents in other countries, to measure the latitude, longitude and altitude of their observing sites. They posted their observations and station locations on the Starshine web site to permit computation of the classical elements of the satellite's orbit by the angles only method of LaPlace.

From day to day, the period of the satellite's orbit grew shorter, due to the afore-mentioned aerodynamic drag. Students measured the magnitude of the daily decrease of period and deduced the density of the earth's upper atmosphere that produced the drag that shortened the satellite's orbital period. They also kept track of fluctuations in intensity of extreme ultraviolet radiation from the sun, as measured by instruments on the Solar and Heliospheric Observatory (SOHO) satellite and posted on the NASA Goddard Space Flight Center SOHO web site. They related fluctuations in intensity of solar activity to changes in the rate of decay of the satellite's orbit and thereby to variations in atmospheric density.

The Starshine 1 satellite consisted of a hollow aluminum sphere, 48 centimeters (19 inches) in diameter, covered with 878 polished aluminum mirrors, each of which was 2.5 centimeters (one inch) in diameter. These mirrors were polished by 25,040 children in 660 schools in 18 countries. The spacecraft was mounted in and spring-deployed from a Hitchhiker canister in the orbiter's cargo bay. The weight of the hollow sphere was 39 kilograms (86.6 pounds). The plane of its orbit at deployment was inclined to the earth's equator by 51.6 degrees.

A second satellite, Starshine 2, was deployed from Space Shuttle Endeavor on December 16, 2001, near the end of Endeavor's STS-108 mission to the International Space Station. The satellite's initial altitude was 370 kilometers (230 statute miles), and its orbital inclination to the earth's equator was 51.6 degrees. The 858 mirrors that covered the outside surface of this satellite were polished by approximately 30,000 students in nearly 700 schools in 26 countries. Engineers at the U.S. Naval Research Laboratory installed the mirrors on the Starshine 2 satellite shell and performed final acceptance vibration testing of the completed satellite, prior to its installation in a Hitchhiker canister at the NASA Goddard Space Flight Center. The satellite is the same size and mass as the Starshine 1 satellite, but it also contains a special cold gas spin system that rotated the satellite at 5 degrees per second as it was deployed from the Space Shuttle orbiter. This motion was designed to increase the number of flashes of sunlight that can be seen as the satellite travels across the sky. In addition, Starshine 2 carries thirty one laser retro-reflectors, distributed evenly across its surface, to permit the International Satellite Laser Ranging Network to track it.

Starshine 2 descended into the lower atmosphere and flamed out on April 26, 2002. The fact that it's orbital lifetime was so much shorter than that of Starshine 1 was due to its slightly lower deployment altitude, coupled with unusually high solar activity during the double peak of solar cycle 23. For further details on the double peak, Click Here: The Resurgent Sun

A third satellite, Starshine 3, was launched on an Athena I unmanned launch vehicle out of the Kodiak Launch Complex, Alaska, on September 29, 2001, into a 470 km (294 statute mile) high circular orbit, inclined 67 degrees to the earth's equator. This orbit was chosen to make the satellite visible to observers located from the equator all the way up to latitudes of 70 degrees north and south of the equator. Starshine 3 was nearly a meter in diameter (37 inches), weighed 91 kilograms (200 pounds) and carried 1500 mirrors that were polished by approximately 40,000 students in 1000 schools in 30 countries.

It also carried thirty one laser retro-reflectors on its surface. Additional instrumentation included an integrated power supply, consisting of combined solar cells and thin film batteries, as well as an amateur radio telemetry transmitter, a command receiver, a rechargeable battery, a secondary solar array, signal-conditioning circuitry, and an antenna array. This satellite was initially spun at 5 degrees per second by its Lightband deployment system, and that spin rate decreased essentially to zero by the end of its third month in orbit, as measured by its radio telemetry system. Starshine 3 completed 7434 orbits of the earth before flaming out in the earth's upper atmosphere on January 21, 2003. This was nearly two years earlier than originally predicted, because of the previously mentioned double peak in Solar Cycle 23.

Starshine 4 is presently being assembled and tested, and its 1000 mirrors have been polished by 1000 schools and other participating groups in 43 countries. A count of the number of participating individuals has not yet been completed. Starshine 4 was originally scheduled for launch on Space Shuttle Atlantis's STS-114 mission to the International Space Station on January 16, 2003. However, it has been removed from the manifest, in favor of a Control Moment Gyro that is needed on the International Space Station to replace one that failed. When Starshine 4 does fly, it will carry 31 optical retroreflectors identical to those on Starshines 2 and 3. It will also carry a Starshine 5 subsatellite in its interior and will release Starshine 5 into its own orbit about one minute after being itself deployed from Atlantis. Comparison of the relative decay rates of the orbits of Starshines 4 and 5 will allow us to derive atmospheric densities more precisely than we have been able to do previously. We really don't know when NASA will find room for Starshine 4/5 on a future Shuttle mission, but it could be as late as the year 2005. We will put a bulletin on this web site when we find out a new launch date.

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